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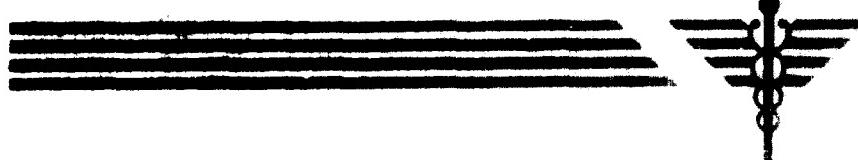
# ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 118  
30 June 1953

## THE RELATION OF POWER AND ENDURANCE TRAINING TO PHYSICAL EFFICIENCY\*

\*Subtask under Human Engineering Studies, AMRL Project No. 6-95-20-001, Subtask, Relation of Physical Training to Operational Performance



RESEARCH AND DEVELOPMENT DIVISION  
OFFICE OF THE SURGEON GENERAL  
DEPARTMENT OF THE ARMY

**REPORT NO. 118**

**THE RELATION OF POWER AND ENDURANCE  
TRAINING TO PHYSICAL EFFICIENCY\***

by

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from

**ARMY MEDICAL RESEARCH LABORATORY  
FORT KNOX, KENTUCKY  
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#### ABSTRACT

#### THE RELATION OF POWER AND ENDURANCE TRAINING TO PHYSICAL EFFICIENCY

#### OBJECT

The object of this project was to compare, under controlled conditions, the changes in physical condition resulting from training for power, for endurance, and for both power and endurance. The initial inquiry related to the need of a varied physical training program for various Military Occupation Specialties.

#### RESULTS

No difference was demonstrated in the training programs involving power, endurance, and a combination of these, under the conditions of this study. All test subjects showed a marked improvement, but there were no appreciable differences in the groups of subjects on each exercise program.

There was a trend evidenced by the results of this study to indicate that muscular endurance is more easily obtained after power has been developed.

#### CONCLUSIONS AND RECOMMENDATIONS

1. Since it was impossible to demonstrate a significant difference between the effects of the basic power and endurance factors in severe physical training, there is no indication for the need of a varied physical training program for different MOSs in the military service.
2. It is a definite impression that the military portion of basic training contributes far more to the over-all improvement in physical condition shown by basic trainees than does the time allotted to formal calisthenics. It is suggested that a further study be undertaken to compare groups of basic trainees who have the regularly allotted time for physical training, which is usually calisthenics, with other groups of basic trainees who have all the military training but not the formal calisthenics.

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## THE RELATION OF POWER AND ENDURANCE TRAINING TO PHYSICAL EFFICIENCY

### I. INTRODUCTION

Department of the Army sources suggested a study of the need for a varied physical training program for different Military Occupation Specialties (MOSs). There was the question of a need for different physical training for men who would do one type of work as opposed to another; for example, infantrymen as compared to more sedentary individuals, such as clerk-typists. Some preliminary investigations indicated that there were far too many MOSs to permit any accurate study of each of them, or even of any significant number of them. For this reason, the question was approached from the basic physiology of physical training involving two factors, power and endurance (1 and 2). It was decided to set up a comparative study between these two factors, and, if a difference could be demonstrated following training, it would lead to further studies of the application of these two factors to the various MOSs as the need arose. It was initially felt that if any differences could be achieved they would be demonstrated by training under two basically different regimens--power and endurance.

Following this comparison between power and endurance, there is a need for comparison between basic trainees who have had the formal calisthenics during the basic training period and those who have had all of the basic training except the formal calisthenics (3). Thus phase of the study will be done at a later date.

There are specific exercises which are thought to develop predominantly endurance, and others which are predominantly for power. Power and endurance are not separable but it was believed that there was sufficient differentiation for the purposes of this study. Power can be defined as the gross strength or energy which can be produced by the muscular system, without regard to the duration or the work accomplished. Endurance can be defined as the time during which a certain energy output can be maintained. For example, weight lifting is mostly power, while distance running and swimming are mostly endurance.

Comparison was made between two groups of test subjects. One group had exclusively power training and the other exclusively endurance training. Comparisons were made by using standard tests of muscular activity and tests of military performance. In cases of severe atrophy of a muscle due to disuse, endurance will not develop until power has been restored (4). Whether power must come before endurance in the training of the normal man is not known. This question was approached by using two additional groups of test subjects. One group developed

power followed by endurance training; the other developed endurance followed by power training. Similar comparative studies were carried out with all four groups of test subjects.

## II. EXPERIMENTAL

### A. Test Subjects

The test subjects were enlisted men who had just entered military service. They were placed in the Test Company by normal assignment procedures so as to obtain a non-specialized sample. These men were trainees assigned to the Third Armored Division at Fort Knox, Kentucky. They came from three different induction stations and were put into the Test Company on a percentage basis from each induction station. They also were selected as a normal per cent of each physical profile and of the area aptitude scores. This provided a Test Company which represented a normal sample of all trainees entering the Division. The subjects were without prior military service or training. This type of individual receives the most intensive physical training during military basic training. The subjects reported directly from the induction stations. Their prior activity ranged from hard work to the most sedentary of occupations.

The test subjects were given the Army Physical Fitness Test (APFT), as outlined in FM 21-20 (5). This test was selected as the criterion for initial division of the test subjects into groups because it is the standard and accepted test of physical fitness in use in the Army at the present time. The composite scores were arranged in order of magnitude. These were then ranked into groups of four. One man from each group was chosen by lot and assigned to one of the four test groups. This resulted in four balanced test groups.

Initially, there was a total of 140 men available for the study. During the time the project was in operation, 24 men were dropped for various reasons. A listing of the men that were dropped and the reasons are given in Appendix A. At the end of the project, there were 30 men in Group I, 31 in Group II, 27 in Group III, and 28 in Group IV.

### B. Exercise Program

Each of the four test groups was subjected to a different exercise program. Group I did power exercises exclusively, which consisted of weight lifting. Group II did power exercises for the first half of the training period, followed by endurance exercises for the second half. Endurance exercises consisted of a variety of calisthenics and running. Group III did endurance exercises for the first half, and power

exercise groups. It served as one test of the change in condition resulting from training. It also gave a rough comparison with the physical training done at all basic training stations. Accurate control of physical training given the subjects permitted an opportunity to check on the validity of this test.

d. The Elgin Muscle Test Table was used for measuring muscle power. This is a standard test used by the Physical Medicine Service, and is of accepted reliability and validity. The muscles tested were those involved in gross body movements, for the most part. Since physical training is chiefly applied to the larger muscles, any change resulting from this training should be found in these muscles. It was impossible to measure all the muscles involved, but those which were measured represented the major muscles or groups which should show a change following exercise.

e. The anthropometric measurements were not a criterion of the exercise program, but were of interest in recording changes in body proportions as a result of heavy exercises (9, 10).

f. The Harvard Step Test was chosen as one check on general condition (2) (11). This test can also be used in a possible comparison with other exercise programs.

g. The 5-mile speed march was used for two reasons. It is a severe test of condition, and is a type of activity currently being stressed in basic training units. It was anticipated that effects of training would be apparent in repeat performances.

h. The 20-mile march was not a criterion, since it could not be scored. It served, however, as a source of observation of the ability to perform prolonged hiking after physical training.

i. The obstacle course was used as a test of actual performance. The speed with which the course was run was considered an indication of physical condition.

j. The treadmill test served as the source of the most reliable measurement of cardiovascular, respiratory, and muscular response to severe exertion (12, 13). The measurements taken were pulse and respiration rates during the recovery period. The rate of recovery following exertion to the point of exhaustion was one of the best indications of physical condition (8).

k. Lactic acid blood levels were determined at the end of exhaustive exercise and served as an index of response to severe exertion. It was anticipated that training would alter the blood level of lactic acid (2, 8, 14, 15, 16).

## **2. Testing Procedures**

The first two weeks of the study were devoted to testing and examination. The history and physical examination, hemoglobin and hematocrit determinations, and the anthropometric measurements occupied the first four days. The fifth day was used for the APFT. The sixth day was used for the Harvard Step Test and the obstacle course. Muscle power testing occupied the first three days of the second week, and the remainder of the week was devoted to the treadmill test and lactic acid determinations. The same order in which each man took the tests was followed at the mid- and end- test periods (see table 2).

The 20-mile hike was taken on the last full training day of the training period in order to avoid altering the sequence of tests during the final two-week test period.

During the mid- and end-test periods, the physical training program was discontinued. The tests themselves were of a sufficiently strenuous nature to prevent appreciable deconditioning.

Appendix C contains the details of each testing procedure, as well as the equipment and personnel which were involved.

## **3. Statistical Methods**

Comparison and analysis of the data were composed of the following: obtaining averages and standard deviations; setting up graphic distributions for each test by group; and finally subjecting the data to a series of single classification analyses of variance. The few significant F values that were found are shown with the particular tables of results.

## **III. RESULTS**

The group scores and figures in all tables are arithmetic means. The various units for scoring and measurement are indicated on each of the tables.

A. THE PERSONAL HISTORY AND PHYSICAL EXAMINATION revealed what would be expected from such a group. Geographical distribution was predominantly from the Great Lakes States - Ohio, Illinois, Indiana, Michigan, Minnesota, and Wisconsin. There were a few men from other areas of the country. Educational level ranged from the fifth grade to college graduates. Type of work was predominantly semi-skilled or laborer. There was a generally high interest in athletics, although there were quite a few men in the Test Company who had apparently participated to a minimum degree, or not at all. The activity for the few

months prior to induction into service was greatly varied. It ranged from the most sedentary occupations such as desk work, clerical work, etc., to extreme hard labor in farming and stevedore work.

Several of the men had inguinal hernias, only one of which was sufficiently severe so as to interfere with the performance of the man's military duty at the beginning of the project. There were a few other minor physical defects, most of which were easily correctable or of such a nature so as not to interfere with the man's performance. Several defects, which were not evident on the initial examination, became evident during the heavy exercise. This was especially true of previous injuries to the knees. All physical defects or injuries of any significance are described and enumerated under the listing of the men who were dropped from the project for various reasons. (See Appendix A.)

B. The HEMOGLOBIN DETERMINATIONS are represented in Table 3. The pre-test figures were within the normal range, the group scores showing a difference of 0.4 gram. There was a slight increase in hemoglobin in all exercise test groups, ranging from 0.4 gram in Group IV to 0.8 gram in Group III.

C. Table 4 contains the results of the HEMATOCRIT DETERMINATIONS where a similar normal level and moderate increase was noted. The largest increase was 4.5 per cent in Group IV, and the lowest was 3.1 per cent in Group I.

D. Tables 5 through 10 show the results of the ARMY PHYSICAL FITNESS TEST. Table 5 shows the total scores based on the five exercises. In the pre-test, the range of individual scores was from 0 to 336, the mid-test from 12 to 357, and the end-test from 11 to 375. There was a marked increase shown by all test groups. The change from pre-test to mid-test was most marked in Group III; the change from mid-test to end-test was most marked in Group IV. The final total change from the beginning to the end was most marked in Group IV, with an increased score of 92.9. The lowest was Group II, with an increased score of 69.6. Table 6 shows the results of the pull-ups, or chinning exercises. It is interesting to note that Group IV showed the largest increase on the APFT total score but actually decreased slightly in the pull-up average score. Groups II and III showed the largest increase in pull-up scores. Table 7 records the results of the squat-jump exercises. Group IV showed the highest increase in the test (40.3 points) while Group II showed the lowest (22.5 points). Table 8 shows the results of the push-ups. Here, again, Group IV showed the greatest increase with 27.3 points. Table 9 shows the results of the sit-up exercises. In this case, Group I showed a 15.7 point increase, and the other groups slightly less. Table 10 shows the results of the 300-yard run. Increases ranged from 8.8 for Group II to

13.3 for Group I over the total exercise period. It is interesting to note that there was a decrease from pre-test to mid-test on the run in Groups I, II and IV.

E. Tables 11 through 16 show the results of the MUSCLE-POWER TESTS, recorded in total pounds handled. The total change on the five-test exercises from pre- to end-test was greatest in Groups I and II, with Group IV showing the least increase. However, there was no great difference between any of them. Table 12 shows the results of the biceps test, which had a slightly greater increase for Group II than for the others. Table 13 shows the results of the triceps measurement, where the total increase showed a difference of less than two pounds for all four groups, indicating a uniform degree of improvement. Table 14 shows the results of the grip test with an increase of 5 to 6.9 pounds for each of the four groups over the total period. Table 15 shows the results of the hip flexors, with a range of increase from 8.6 pounds for Group I to 12.8 pounds for Group II. Table 16 shows the results of the quadriceps measurement, with an increase ranging from a total of 22.1 pounds for Group IV to 31.3 pounds for Group I.

Tables 17 through 22 are also based on the muscle-power tests; however, the results are shown as the ratio of weight lifted to body weight. Table 17 shows the results of the total of the five tests. It is interesting to note that the greatest increase occurred from the pre- to mid-test, that is, during the early part of the training. The total increase showed a relatively uniform rate, with a low of 26.9 for Group IV to a high of 35.3 for Group II. Table 18 shows the results of the biceps measurement, with an increase ranging from 2.8 to 5.2. The triceps test showed similar results (Table 19). Table 20 shows the grip ratio to body weight, with only a slight increase for each exercise group. Table 21 shows the results of the hip flexors, with an increase of 4.1 to 7.1. Table 22 shows the results of the quadriceps measurement, with a range of increase from 12.9 to 17.1. In all cases, the greatest increase occurred during the first exercise period. It is interesting to note that when the total weight handled was considered as a ratio related to the body weight, the rate of increase was more uniform throughout all groups than when it was considered as total pounds handled with no regard for body size.

F. Tables 23 through 33 show the results of various ANTHROPO-METRIC MEASUREMENTS. Table 23 shows the results of the body weight measurements. There was only a slight increase from pre- to mid-test, with a considerably larger increase for mid-test to end-test. The total increase for the exercise period ranged from 4.0 pounds for Group IV to 7.2 pounds for Group II. The other body measurements showed relatively little change. The only consistent changes which were

found as increases in all groups, were in the circumferences of the arms and legs.

G. Table 34 shows the results of the HARVARD STEP TEST. The results of this test showed a steady increase for all exercise groups, with the maximum improvement being shown by Group IV with a 33.6 point increase, and the minimum by Group III with a 23.6 point increase. The ranges of scores varied from a low score of 15 for the pre-test to a high score of '05 on the end-test. Even though the extreme scores showed very little change, the total improvement for the groups as shown by the means, was considerable.

H. Table 35 shows the results of the FIVE-MILE SPEED MARCH. This test was run only at the mid-test and end-periods. For the mid-to end-test, there was a marked decrease in time needed to run this test. Group II showed the least improvement, with a decrease of 6 min. 24 sec. and Group IV showed the greatest improvement, with a decrease of 7 min. 54 sec. The longest time needed to run the course was 1 hr. 32 min. 6 sec. on the mid-test, and the shortest was 45 min. 1 sec. on the end-test.

I. The 20-MILE HIKE was performed for observation purposes only, and was not scored. The opinions were those of the officers and military cadre observing the trainees during the 20-mile hike. The uniform opinion of the observing group was that there was no appreciable difference between the performance of the different exercise groups. It might be noted that 110 men from the Test Company took the hike and that none fell out. The entire group completed the hike at the planned rate of march, or slightly faster.

J. Table 36 shows the results of the OBSTACLE COURSE TEST. The initial scores were rather similar in all exercise groups and remained so throughout, with each group showing a considerable decrease in time needed to run the course. Greater improvement was shown from pre- to mid-test than from mid- to end-test. The total increase was similar for all groups.

K. Tables 37 through 41 show the results of the TREADMILL TEST. Table 37 shows the total time in minutes and seconds which were run on the mill. All exercise groups showed an increase. The increase ranged from 18 seconds for Group II to 23 seconds for Groups I and IV, from pre- to end-test. The range of scores for the entire group was from a low score of 5 min. 5 sec. during the pre-test to a high of 8 min. 54 sec. on the end-test. Table 38 shows the results of the initial pulse rate count. There was an amazing uniformity throughout the entire test group. Table 39 shows the results of the recovery time in minutes.

There was a slight decrease in recovery time in all groups. The extreme scores ranged from 3 to 21 minutes. Table 40 shows the initial respiration rate count. There was a slight increase from pre- to mid-test and practically no change from mid- to end-test. Table 41 shows the final respiration rate count. There was practically no change throughout the entire test period.

L. Table 42 shows the results of the LACTIC ACID DETERMINATIONS. Due to a technical error in method the results of the test are not recorded for the pre-test period. The recorded results show a considerable variation ranging from a decrease in blood lactic acid level of 7.1 mg. per cent for Group I, to a maximum decrease of 26.1 mg. per cent for Group II.

#### IV. DISCUSSION

It is well recognized that there are several factors involved in muscular performance, however, power and endurance can be readily changed by physical training. Such things as coordination, reaction time, and what might well be called general athletic ability, are predominant characteristics which the man has or does not have, and are not readily changed by training. It was felt that sufficient differentiation could be made between power and endurance for the purposes of this study, while it is well understood that there is no complete separation of the two.

It was decided that the type of exercise which most nearly approached pure power was that of weight lifting or weight training. The strong advocates of weight lifting as a training exercise have maintained that it is also an excellent developer of condition or endurance. This was found to be generally the case in this study. The weight training or exercise program was that outlined by Hoffman (21). This was not used in the belief that it was the only group of exercises which would be suitable, but because of its wide-spread usage in weight-training programs.

The endurance program was varied according to the detailed description given in Appendix B. It was selected for the types of exercises which require both high-speed and multiple repetitions with relatively low resistance.

During the military training, considerable time was devoted to observations of the physical aspects of the military training program with an attempt to evaluate the degree of influence this had on the testing program. These observations lead to the impression that, even with the large amount of time which was devoted to physical training with this group, the physical improvement as a result of the regular military basic training was at least equal to the formal physical exercise which was given.

There were two factors which greatly influenced the total improvement of the test subjects. One was the fact that they composed an experimental unit and, as such, were set apart from the ordinary run-of-the-mill basic trainees. This contributed to the high state of morale and interest in the exercises. The other factor was the unusually superior cadre who were in charge of these men.

During the entire 16 weeks of training, there was not one case of absence without leave in the Test Company. There was only one case of punishment for a minor infraction of rules. The general spirit of the men was excellent, and continued so throughout the entire project. Because of these factors it is difficult to compare this group with any other group of basic trainees. The motivation factor is one of prime importance in any physical performance, but is extremely difficult to measure under most circumstances.

The medical history and physical examination revealed nothing of particular importance, but resulted in the confidence that everything had been done to eliminate any physically unqualified men. The personal history forms gave some general information about the test subjects and their background, but the group was not sufficiently large to make any significant comparisons as to prior physical activity, geographical location, etc. The hemoglobin and hematocrit determinations both showed a moderate increase during the test period. This was probably due to the increased food intake as well as the severity of the physical exercise. There was not enough difference between groups for any pertinent comparisons to be made.

In the analyses of variance performed on each of the tests significant F's were obtained only for blood lactic acid level, the hematocrit, and the final respiration rate count following recovery from the treadmill run (Tables 4, 41 and 42). Of greater interest than the isolated significant F's which were obtained is the fact that so few were found in the series of 57 analyses of variance which were performed. The over-all finding of this series of analyses is that there was no essential differentiation between power and endurance or combinations of them under the conditions of this study.

There were, however, some very interesting comparisons between tests. It is believed that the Army Physical Fitness Test, the obstacle course, and the Harvard Step Test are the most reliable and valid tests for performance that were used in this study.

The Army Physical Fitness Test seems to cover the ordinary range of power and endurance performance adequately. There are some potential sources of error in the test which are primarily those of administration rather than within the test itself. It is easy to become lax in

scoring. In almost all cases, there was a marked improvement shown by the Army Physical Fitness Test scores. There were a few individual cases where there was a decrease in scores, either on the mid- or the end-test period; however, with one exception, these cases could be explained by a marked reduction in motivation on the part of the particular man, either because of personal or other problems which had a direct influence on his performance.

The scores for the Harvard Step Test showed a generalized improvement in almost all test subjects. If the Harvard Step Test were a test of endurance, Group IV would be expected to show the highest improvement, which it did; however, Group III, which had half the endurance training, showed the least improvement. The greatest source of error in the Harvard Step Test probably lies in the fact that there is a marked difference in energy output required for a man who is, say, 6 feet tall, to step up and down on a 20-inch step as compared with a man who is 5 feet 6 inches. There is no allowance made for the height of the man. However, if this test is used to demonstrate a man's improvement over his previous scores, this defect is eliminated.

The scores for the obstacle course also showed a marked increase in physical performance. The greatest improvement was shown in Groups I and II, which were the power exercise groups. There is no obvious explanation for this. It had been believed that the obstacle course was predominately a test of endurance. However, it appears that muscular power and strength are of at least equal if not of greater importance in this test.

The 5-mile speed march proved an interesting test to administer, and showed definite improvement in scores. In almost all cases, there was a decrease in running time. The greatest decrease in running time occurred in Groups III and IV, which was expected because of the type of exercise training. This proved to be a very strenuous test of endurance. The course was actually 5.6 miles over rather roughly-graveled road, with two large hills. It is felt that one important reason for the improvement on this particular test was the development of confidence on the part of each man that he could run such a distance in a fairly short time. The initial run came after part of the training had been completed and each man had gained some confidence. However, the course was completely new, and most men had never attempted such a feat of endurance before that time. On the final test, the men were familiar with the course and each had an increased confidence in his ability. Several of the men were so interested in running this test that they pushed themselves almost to the exhaustion point in order to make a good showing.

The muscle power tests were an attempt to measure the gross muscular strength of five different muscles or muscle groups. An attempt

was made to eliminate factors of great variability in the method of performing the tests so as to get the one-repetition maximum as nearly accurate in each case as possible. The same group of men administered and scored the tests in each case. There was a marked improvement in all groups, mostly in Groups I and II, but the difference between groups was not great. The five-test total shows a range of improvement of only 15 pounds in all groups. When the improvement is based on the body weight ratio of the man, the improvement is reduced to an 8 per cent range within all four groups. This is not significant, and, for practical purposes, the test subjects who were trained for endurance showed almost as much improvement in power as those supposedly trained for power.

The treadmill test was the most severe test for endurance. There was a great interest on the part of the test subjects in this activity, partly because it was a test where the man performing it was being closely observed by his fellow-soldiers and was, consequently, well motivated to make a good showing. In several cases, men were so interested and so highly motivated that they performed this test to the point of absolute exhaustion. On the other hand, some men obviously did not run to the point of even approaching exhaustion. This is a potential source of the differences in the pulse counts, the recovery times, and the lactic acid determinations which followed this test. The only thing which made the test valid was that, in general, each subject was motivated to a similar extent each time he took the test. Those who ran the hardest did so each time. The men who ran top scores remained in relatively the same position to the entire group. A few low-score men continued to remain low, primarily because of a low motivation factor, as well as a limited physical ability. There was little change in the mean pulse rate of the four groups. The recovery time, in each test group and in each test period, showed a slight decrease, but was not significant. The respiration counts, both the initial and the terminal counts, were similar in all groups and indicated slight or no change following training. The greatest change occurring in this test was in the running time. This leads to the belief that most of the men did put out a sincere effort, as evidenced by the fact that on the end-test their initial pulse count, after completing the test, was similar to the pre- and mid-test, while the running time showed a considerable increase. This indicates that their general condition had improved, and while the motivation remained fairly constant, they were capable of producing considerably longer energy outputs than they were prior to the training.

The lactic acid determinations showed one of the greatest between-group differences of any test which was administered. Interpretation of this difference is difficult. From a study of the literature, it seems that there are two schools of thought on changes of lactic acid blood

levels following exhaustive exercise with and without prior physical training. One hypothesis contends that the body, particularly the muscular system, becomes able to operate with a much higher blood lactic acid level following training than before training. That is, the man trained for long and severe exhaustive exercise could operate with a higher lactic acid blood level than the man attempting to do such exercise without prior physical training. The other hypothesis is that physical training produces an increased efficiency in the metabolism of lactic acid. Consequently, the person is able to do severe exercise for a longer period of time without an accumulation of lactic acid to the point where it would prevent further muscular activity.

All four groups show a decrease in lactic acid blood level. The decrease from the mid-test to the end-test was definite, while there was a corresponding increase in the length of time run on the treadmill. This means that with a greater energy output there was a decrease of blood lactic acid level. This seems to indicate an increased efficiency in metabolism. This test showed that Group II demonstrated the greatest improvement in physical condition.

While the other tests did not show marked differences between the groups, there is one other factor to support the contention that Group II showed the greatest improvement. When the entire battery of tests were arranged to indicate which group showed the first, second, third, and fourth places in amount of improvement. Group II was the one with the greatest number of first-place increases. The total improvement from pre- to end-test was used for this comparison. Group II showed first-place improvement in 14 of the measurements. The next best was Group I, which showed 10 first-place improvements. Group III showed 9, and Group IV showed 7. The differences were not tested for statistical significance, however it is felt that Group II showed the greatest improvement in view of the observation of the entire exercise program and of the extensive degree of testing. The only single test which gives direct support to this conclusion is the lactic acid determination. Such a conclusion as this is in agreement with the conclusion of De Lorme, that power must be increased before endurance can be increased (4). Group II had power exercises first, followed by endurance training.

The large number of physical measurements which were done revealed no major differences between the groups. It is interesting to note, however, that the changes in body proportions had a tendency to neutralize each other--the fat men became leaner and the lean men filled out with well-developed muscles. Throughout the entire Test Company, there was a slight increase in weight.

V CONCLUSIONS

There are two conclusions that may be drawn from this study:

1. There was no statistically significant difference demonstrated between the exercise programs of power and endurance as conducted in this study.
2. There was some tendency evidenced by the results of this study to indicate that muscular endurance is more easily obtained after power has been developed.

VI. RECOMMENDATIONS

1. Since it was impossible to demonstrate a significant difference between the effects of the basic power and endurance factors in severe physical training, there is no indication for the need of a varied physical training program for different MOSs in the military service.
2. It is a definite impression that the military portion of basic training contributes far more to the over-all improvement in physical condition shown by basic trainees than does the time allotted to formal calisthenics. It is suggested that a further study be undertaken to compare groups of basic trainees who have the regularly allotted time for physical training, which is usually calisthenics, with other groups of basic trainees who have all the military training but not the formal calisthenics.

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VIII. TABLES

TAR  
TESTS AND UNITS MEASUREMENT

<u>Test</u>	<u>Unit</u>
1. History & Physical Examination	None. Information only.
2. Hemoglobin	Grams in 0.1 gm units. 14.0-18.0 gm range.
3. Hematocrit	Per cent in units of 1.0. 40-55% range.
4. Army Physical Fitness Test	Abstract Score from prepared table. Range 0-500.
5. Muscle Power	Weight in pounds moved for each muscle group.
6. Anthropometric Height Weight Various Circumferences	Inches to 1/4 inch. Pounds to 1/4 lb. Inches to 1/4 inch.
7. Harvard Step Test	Abstract Score from prepared table. Possible range 5-130.
8. Five-Mile Speed March	Time in minutes and seconds.
9. Twenty-mile Hike	None. Observation only.
10. Obstacle Course	Time in minutes and seconds.
11. Treadmill Test Pulse	Rate per 30 seconds at end of exercise and until rate falls below 100/min. during recovery period. (Counted for 30 sec. out of each minute.)
Recovery Time	Time in minutes from end of exercise until pulse rate below 100/min.
Respiration	Rate per 30 seconds at end of exercise and until pulse falls below 100/min. during recovery period (Counted for 30 sec. out of each minute.)
12. Lactic Acid Blood Test	Mg per cent in units of 0.1.

TABLE I  
SCHEDULE OF TESTS

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Pre-Test					
H & P Hb & Hct Anthro	H & P Hb & Hct Anthro	H & P Hb & Hct Anthro	H & P Hb & Hct Anthro	APFT	Step Obstacle
Power	Power	Power Treadmill & Lactic	Treadmill & Lactic	Treadmill & Lactic	Treadmill
Mid-Test					
APFT Hb & Hct	Step Hb & Hct	Obstacle Hb & Hct	Power	Power	Power
5-Mile March Anthro	Treadmill Anthro	Treadmill Anthro	Treadmill	Treadmill	Treadmill
End-Test					
(20 Miles on prior Fri) APFT Hb & Hct	Step Hb & Hct	Obstacle Hb & Hct	Power	Power	Power
5-Mile March Anthro	Treadmill Anthro	Treadmill Anthro	Treadmill	Treadmill	Treadmill

H & P - History and physical examination.

Hb & Hct - Hemoglobin and hematocrit.

APFT - Army Physical Fitness Test.

TABLE 1

HEMOGLOBIN (Unit: Grams)

GROUP	I	II	III	IV
Score Pre-Test	14.9	15.0	14.7	15.1
Score Mid-Test	15.0	15.1	15.1	14.9
Score End-Test	15.5	15.6	15.5	15.5
Change Pre-Mid	+ 0.1	+ 0.1	+ 0.4	- 0.2
Change Mid-End	+ 0.5	+ 0.5	+ 0.4	+ 0.6
Change Pre-End	+ 0.6	+ 0.6	+ 0.8	+ 0.4
Range of Scores for Entire Group	14.0-18.1	13.2-17.4	13.8-19.0	

Group I - Power exercises.

Group II - Power exercises followed by endurance exercises.

Group III - Endurance exercises followed by power exercises.

Group IV - Endurance exercises.

TABLE 4

HEMATOCRIT (Unit: Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	43.7	44.7	45.9	45.9
Score Mid-Test	43.8	47.4	46.2	47.2
Score End-Test	48.0	48.5	49.5	49.5
Change Pre-Mid	- 0.1	+ 2.7	+ 0.3	+ 2.3
Change Mid-End	+ 3.2	+ 1.1	+ 1.3	+ 2.3
Change Pre-End	+ 3.1	+ 3.8	+ 3.6	+ 4.5
Range of Scores for Entire Group	38.5-50.9	39.2-54.2	42.2-54.5	

Group I - Power exercises.

Group II - Power exercises followed by endurance exercises.

Group III - Endurance exercises followed by power exercises.

Group IV - Endurance exercises.

## SIGNIFICANCE TESTS FOR HEMATOCRIT

	Sum of Squares	df	F
Pre-Test - Mid-Test Scores	100.15	3	3.22*
	1029.04	92	
Mid-Test - End-Test Scores	101.99	3	3.02*
	1214.19	108	
Pre-Test - End Test Scores	21.38	3	0.41
	1619.24	92	

\*The 5% level of significance = 2.70

**TABLE**  
**ARMY PHYSICAL FITNESS TEST S-TEST TOTALS**

GROUP	(Unit: Points Scored)			
	I	II	III	IV
Score Pre-Test	129.1	128.4	123.4	126.4
Score Mid-Test	134.5	160.0	183.2	157.9
Score End-Test	203.5	198.0	210.7	219.3
Change Pre-Mid	+ 31.4	+ 32.4	+ 59.8	+ 31.5
Change Mid-End	+ 49.0	+ 17.2	+ 27.5	+ 61.4
Change Pre-End	+ 80.4	+ 59.6	+ 87.3	+ 92.9
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	0-336	12-357	11-375	

Group I - Power Exercises.  
 Group II - Power exercises followed by endurance exercises.  
 Group III - Endurance exercises followed by power exercises.  
 Group IV - Endurance exercises.

**TABLE**  
**ARMY PHYSICAL FITNESS TEST PULL UPS**

GROUP	(Unit: Points Scored)			
	I	II	III	IV
Score Pre-Test	27.7	28.8	27.4	30.1
Score Mid-Test	29.1	35.8	34.2	29.5
Score End-Test	33.4	36.7	35.0	29.5
Change Pre-Mid	+ 1.4	+ 6.8	+ 6.8	- 0.6
Change Mid-End	+ 4.3	+ 1.1	+ 0.8	± 0
Change Pre-End	+ 5.7	+ 7.9	+ 7.6	- 0.6
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	0-87	0-87	0-87	

**TABLE**  
**ARMY PHYSICAL FITNESS TEST SQUAT JUMPS**

GROUP	(Unit: Points Scored)			
	I	II	III	IV
Score Pre-Test	38.7	37.0	39.4	31.8
Score Mid-Test	53.5	49.9	61.2	53.1
Score End-Test	68.4	59.5	72.3	72.1
Change Pre-Mid	+ 15.8	+ 12.9	+ 21.8	+ 21.5
Change Mid-End	+ 10.9	+ 9.6	+ 11.1	+ 10.8
Change Pre-End	+ 27.7	+ 22.5	+ 32.9	+ 40.3
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	0-100	0-100	0-100	

TABLE 8  
ARMY PHYSICAL FITNESS TEST: PUSH-UPS

GROUP	(Unit: Points Scored)			
	I	II	III	IV
Score Pre-Test	17.0	15.9	16.1	19.3
Score Mid-Test	24.0	25.7	33.2	34.4
Score End-Test	35.8	34.3	38.4	46.6
Change Pre-Mid	+ 6.2	+ 9.8	+17.1	+15.1
Change Mid-End	+11.8	+ 8.8	+ 3.2	+12.2
Change Pre-End	+18.0	+18.4	+22.3	+27.3
Range of Scores for Entire Group	Pre-Test 0-73	Mid-Test 0-77	End-Test 0-93	

TABLE 9  
ARMY PHYSICAL FITNESS TEST: SIT-UPS

GROUP	(Unit: Points Scored)			
	I	II	III	IV
Score Pre-Test	22.7	28.0	21.2	25.6
Score Mid-Test	30.4	36.7	34.5	30.4
Score End-Test	38.4	40.0	33.6	39.4
Change Pre-Mid	+ 7.7	+ 8.7	+13.3	+ 4.8
Change Mid-End	+ 8.0	+ 3.3	+ 1.1	+ 9.0
Change Pre-End	+15.7	+12.0	+14.4	+13.8
Range of Scores for Entire Group	Pre-Test 0-70	Mid-Test 0-76	End-Test 0-82	

TABLE 10  
ARMY PHYSICAL FITNESS TEST: 300-YARD RUN

GROUP	(Unit: Points Scored)			
	I	II	III	IV
Score Pre-Test	16.2	18.7	19.3	19.6
Score Mid-Test	15.5	12.9	20.1	10.3
Score End-Test	29.5	27.3	29.4	31.7
Change Pre-Mid	- 0.7	- 5.8	+ 0.8	- 9.3
Change Mid-End	+14.0	+14.6	+ 9.3	+21.4
Change Pre-End	+13.3	+ 8.6	+10.1	+12.1
Range of Scores for Entire Group	Pre-Test 0-59	Mid-Test 0-65	End-Test 0-65	

TABLE I  
MUSCLE POWER: D-TEST TOTALS

GROUP	I	II	III	IV
Score Pre-Test	353.6	350.4	336.6	348.2
Score Mid-Test	392.6	392.0	373.0	378.5
Score End-Test	414.6	418.1	384.2	398.4
Change Pre-Mid	+ 39.0	+ 42.4	+ 36.4	+ 30.3
Change Mid-End	+ 22.0	+ 23.3	+ 21.2	+ 20.9
Change Pre-End	+ 61.0	+ 65.7	+ 57.6	+ 51.2
Range of Scores for Entire Group	Pre-Test 315-492.5	Mid-Test 250-510	End-Test 277.5-547.5	

Group I - Power exercises.

Group II - Power exercises followed by endurance exercises

Group III - Endurance exercises followed by power exercises

Group IV - Endurance exercises

TABLE II  
MUSCLE POWER: BICEPS

GROUP	I	II	III	IV
Score Pre-Test	47.1	46.5	46.7	45.4
Score Mid-Test	51.4	50.7	50.0	48.9
Score End-Test	54.7	56.0	52.9	52.6
Change Pre-Mid	+ 4.3	+ 4.2	+ 3.3	+ 3.5
Change Mid-End	+ 3.3	+ 5.3	+ 2.9	+ 3.7
Change Pre-End	+ 7.6	+ 9.5	+ 6.2	+ 7.2
Range of Scores for Entire Group	Pre-Test 30-70	Mid-Test 30-75	End-Test 35-75	

TABLE III  
MUSCLE POWER: TRICEPS

GROUP	I	II	III	IV
Score Pre-Test	25.8	26.3	23.8	25.1
Score Mid-Test	28.0	20.6	28.1	28.0
Score End-Test	32.8	33.7	31.6	31.3
Change Pre-Mid	+ 2.2	+ 4.3	+ 4.3	+ 2.9
Change Mid-End	+ 4.8	+ 3.1	+ 3.5	+ 3.3
Change Pre-End	+ 7.0	+ 7.4	+ 7.8	+ 6.2
Range of Scores for Entire Group	Pre-Test 12.5-40	Mid-Test 15-47.5	End-Test 20-50	

TABLE 14  
MUSCLE POWER: GRIP  
(Unit: Pounds)

GROUP	I	II	III	IV
Score Pre-Test	129.7	129.7	124.6	128.4
Score Mid-Test	136.4	134.7	130.0	131.8
Score End-Test	136.2	136.0	131.5	133.4
Change Pre-Mid	+ 6.7	+ 7.0	+ 5.4	+ 3.4
Change Mid-End	- 0.2	- 0.7	+ 1.5	+ 1.6
Change Pre-End	+ 6.5	+ 6.3	+ 6.9	+ 5.0
Range of Scores for Entire Group	Pre-Test 85-190	Mid-Test 90-180	End-Test 100-185	

TABLE 15  
MUSCLE POWER: HIP FLEXORS  
(Unit: Pounds)

GROUP	I	II	III	IV
Score Pre-Test	58.1	58.2	55.0	58.8
Score Mid-Test	63.8	65.2	61.6	63.0
Score End-Test	66.7	69.0	65.6	67.3
Change Pre-Mid	+ 5.7	+ 9.0	+ 6.6	+ 6.4
Change Mid-End	+ 2.9	+ 3.0	+ 4.0	+ 4.3
Change Pre-End	+ 8.6	+12.8	+10.6	+10.7
Range of Scores for Entire Group	Pre-Test 30-110	Mid-Test 37.5-115	End-Test 52.5-117.5	

TABLE 16  
MUSCLE POWER: QUADRICEPS  
(Unit: Pounds)

GROUP	I	II	III	IV
Score Pre-Test	92.9	93.7	86.5	92.7
Score Mid-Test	113.0	111.6	103.3	106.0
Score End-Test	124.2	123.4	112.6	114.8
Change Pre-Mid	+20.1	+17.9	+16.8	+14.1
Change Mid-End	+11.2	+11.8	+ 9.3	+ 8.0
Change Pre-End	+31.3	+29.7	+26.1	+22.1
Range of Scores for Entire Group	Pre-Test 40-155	Mid-Test 60-170	End-Test 62-215	

TABLE 17

**MUSCLE POWER RATIO S-TEST TOTALS**  
 (Unit: Pounds/Body Weight as Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	227.0	224.5	221.5	226.0
Score Mid-Test	247.7	217.2	242.2	243.6
Score End-Test	258.6	259.8	250.0	252.9
Change Pre-Mid	+20.7	+22.7	+20.7	+17.6
Change Mid-End	+8.9	+12.6	+7.0	+9.3
Change Pre-End	+29.6	+15.3	+28.5	+26.9
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	148-293	169-319	172-331	

Group I - Power exercises.

Group II - Power exercises followed by endurance exercises.

Group III - Endurance exercises followed by power exercises.

Group IV - Endurance exercises

TABLE 18

**MUSCLE POWER RATIO BICEPS**

(Unit: Pounds/Body Weight as Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	30.2	29.9	30.7	29.4
Score Mid-Test	32.5	32.0	32.4	31.4
Score End-Test	34.0	35.1	33.5	33.3
Change Pre-Mid	+2.3	+2.1	+1.7	+2.0
Change Mid-End	+1.5	+3.1	+1.1	+1.9
Change Pre-End	+3.8	+5.2	+2.8	+3.9
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	19.7-41.1	20.3-43.2	21.7-48.5	

TABLE 19

**MUSCLE POWER RATIO TRICEPS**

(Unit: Pounds/Body Weight as Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	16.4	16.8	15.7	16.2
Score Mid-Test	17.4	17.7	18.2	17.9
Score End-Test	19.7	21.1	20.0	19.8
Change Pre-Mid	+1.0	+2.4	+2.5	+1.7
Change Mid-End	+2.3	+1.0	+1.8	+1.9
Change Pre-End	+3.3	+4.3	+4.3	+3.6
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	7.9-24.7	10.4-27.7	12-30.6	

TABLE 20  
MUSCLE POWER RATIO: GRIP  
(Unit: Pounds/Body Weight as Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	83.4	82.1	82.1	83.8
Score Mid-Test	86.3	84.8	84.6	85.2
Score End-Test	84.7	83.7	83.6	84.6
Change Pre-Mid	+ 2.9	+ 2.7	+ 2.5	+ 1.3
Change Mid-End	- 1.6	- 1.1	- 1.0	- 0.6
Change Pre-End	+ 1.3	+ 1.6	+ 1.5	+ .7
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	51.1-123.9	60.5-121.4	61.8-122.3	

TABLE 21  
MUSCLE POWER RATIO: HIP FLEXORS  
(Unit: Pounds/Body Weight as Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	37.5	36.2	36.1	36.7
Score Mid-Test	40.4	41.3	39.9	40.6
Score End-Test	41.6	43.3	41.5	42.5
Change Pre-Mid	+ 2.9	+ 5.1	+ 3.8	+ 3.9
Change Mid-End	+ 1.2	+ 2.0	+ 1.6	+ 1.9
Change Pre-End	+ 4.1	+ 7.1	+ 5.4	+ 5.8
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	17.6-47.7	21.9-65.1	21.6-67	

TABLE 22  
MUSCLE POWER RATIO: QUADRICEPS  
(Unit: Pounds/Body Weight as Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	59.5	59.5	56.9	59.8
Score Mid-Test	71.1	69.9	67.1	68.5
Score End-Test	76.6	76.6	71.4	72.7
Change Pre-Mid	+11.6	+10.4	+10.2	+ 8.7
Change Mid-End	+ 5.5	+ 6.7	+ 4.3	+ 4.2
Change Pre-End	+17.1	+17.1	+14.5	+12.9
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	31.4-87.3	38.6-94.5	41.4-99.7	

TABLE 13  
PHYSICAL MEASUREMENTS: WEIGHT  
(Unit: Pounds)

GROUP	I	II	III	IV
Score Pre-Test	159.0	158.9	152.5	154.8
Score Mid-Test	160.0	159.5	156.3	158.4
Score End-Test	163.9	164.1	158.0	158.0
Change Pre-Mid	+ 1.0	+ 2.6	+ 1.8	+ 1.6
Change Mid-End	+ 3.1	+ 4.6	+ 3.7	+ 2.4
Change Pre-End	+ 4.9	+ 7.2	+ 5.5	+ 4.0
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	118-234.75	115.25-238.5	128-236	

Group I - Power exercises.  
Group II - Power exercises followed by endurance exercises.  
Group III - Endurance exercises followed by power exercises.  
Group IV - Endurance exercises.

TABLE 14  
PHYSICAL MEASUREMENTS: NECK CIRCUMFERENCE  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	14.5	14.6	14.4	14.4
Score Mid-Test	14.5	14.5	14.4	14.4
Score End-Test	14.6	14.6	14.5	14.5
Change Pre-Mid	± 0.0	± 0.1	± 0.0	± 0.0
Change Mid-End	+ 0.1	+ 0.1	+ 0.1	+ 0.1
Change Pre-End	+ 0.1	+ 0.0	+ 0.1	+ 0.1
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	12.75-16.5	12.5-16.25	13-16.5	

TABLE 15  
PHYSICAL MEASUREMENTS: UPPER ARM (RELAXED)  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	11.7	11.6	11.2	11.4
Score Mid-Test	11.8	11.6	11.4	11.1
Score End-Test	12.0	11.8	11.7	11.6
Change Pre-Mid	+ 0.1	± 0.0	+ 0.2	- 0.3
Change Mid-End	+ 0.2	+ 0.2	+ 0.3	+ 0.5
Change Pre-End	+ 0.3	+ 0.2	+ 0.5	+ 0.2
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	9-15	9-15.25	9.75-15	

TABLE 26  
PHYSICAL MEASUREMENTS UPPER ARM (TENSED)  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	12.0	12.4	12.2	12.4
Score Mid-Test	12.0	12.7	12.5	12.5
Score End-Test	12.0	12.0	12.7	12.7
Change Pre-Mid	+ 0.2	+ 0.3	+ 0.3	+ 0.1
Change Mid-End	+ 0.2	+ 0.1	+ 0.2	+ 0.2
Change Pre-End	+ 0.4	+ 0.4	+ 0.5	+ 0.3
Range of Scores for Entire Group	9.5-15.75	9.5-16.25	10.25-16	

TABLE 27  
PHYSICAL MEASUREMENTS FOREARM  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	11.1	11.1	10.9	10.9
Score Mid-Test	11.2	11.2	11.1	11.0
Score End-Test	11.3	11.3	11.2	11.1
Change Pre-Mid	+ 0.1	+ 0.1	+ 0.2	+ 0.1
Change Mid-End	+ 0	+ 0.1	+ 0.1	+ 0.1
Change Pre-End	+ 0.2	+ 0.2	+ 0.3	+ 0.2
Range of Scores for Entire Group	9.25-19.5	9.25-19.5	9.75-12.5	

TABLE 28  
PHYSICAL MEASUREMENTS CHEST (NATURAL)  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	37.0	36.8	36.1	36.5
Score Mid-Test	37.1	37.0	36.5	36.5
Score End-Test	37.2	37.0	36.8	36.4
Change Pre-Mid	+ 0.1	+ 0.2	+ 0.4	+ 0.0
Change Mid-End	+ 0.1	+ 0.0	+ 0.1	- 0.1
Change Pre-End	+ 0.2	+ 0.2	+ 0.5	- 0.1
Range of Scores for Entire Group	31.75-45.25	32-46	32-45	

TABLE 29  
PHYSICAL MEASUREMENTS CHEST (EXPIRATION)

GROUP	(Unit Inches)			
	I	II	III	
Score Pre-Test	38.2	35.9	35.3	35.8
Score Mid-Test	38.2	35.9	35.7	35.8
Score End-Test	35.1	35.8	35.8	35.5
Change Pre-Mid	± 0.0	± 0.0	+ 0.4	- 0.2
Change Mid-End	- 1.1	- 0.1	+ 0.2	- 0.1
Change Pre-End	- 1.1	0.1	+ 0.6	- 0.3
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	31.5-44.75	31.75-44.75	31.75-44	

TABLE 30  
PHYSICAL MEASUREMENTS CHEST (INSPIRATION)

GROUP	(Unit Inches)			
	I	II	III	
Score Pre-Test	38.4	38.0	37.4	38.0
Score Mid-Test	38.6	38.5	38.2	38.2
Score End-Test	38.9	38.6	38.3	38.1
Change Pre-Mid	+ 0.2	+ 0.5	+ 0.8	+ 0.2
Change Mid-End	+ 0.3	+ 0.1	+ 0.1	- 0.1
Change Pre-End	+ 0.5	+ 0.6	+ 0.9	+ 0.1
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	32.25-46.25	33.25-46.75	33.25-46	

TABLE 31  
PHYSICAL MEASUREMENT ABDOMEN (CIRCUMFERENCE)

GROUP	(Unit Inches)			
	I	II	III	
Score Pre-Test	31.9	31.5	30.8	31.2
Score Mid-Test	31.5	31.3	30.8	30.8
Score End-Test	31.9	31.2	31.1	31.0
Change Pre-Mid	0.4	0.2	± 0.0	- 0.5
Change Mid-End	+ 0.4	- 0.1	+ 0.3	+ 0.2
Change Pre-End	± 0.0	- 0.3	+ 0.3	- 0.3
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	26.75-43	27-42.75	26.25-42	

TABLE 12

PHYSICAL MEASUREMENTS - THIGH  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	21.0	20.8	20.4	20.7
Score Mid-Test	21.2	21.2	20.7	20.8
Score End-Test	21.6	21.4	21.1	21.3
Change Pre-Mid	+ 0.2	0.4	+ 0.3	+ 0.1
Change Mid-End	+ 0.4	+ 0.2	+ 0.4	+ 0.5
Change Pre-End	+ 0.6	+ 0.6	+ 0.7	+ 0.6
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	17.5-26.75	19-26	19.5-26	

TABLE 13

PHYSICAL MEASUREMENTS - CALF  
(Unit: Inches)

GROUP	I	II	III	IV
Score Pre-Test	14.6	14.4	14.2	14.5
Score Mid-Test	14.6	14.6	14.3	14.6
Score End-Test	14.6	14.5	14.5	14.6
Change Pre-Mid	+ 0.0	0.2	+ 0.1	+ 0.1
Change Mid-End	+ 0.2	0.1	+ 0.2	+ 0.2
Change Pre-End	+ 0.2	0.1	+ 0.3	+ 0.3
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	12.5-17.5	12.75-17.75	12.5-18	

TABLE 14

HARVARD STEP TEST  
(Unit: Points)

GROUP	I	II	III	IV
Score Pre-Test	44.4	44.1	45.7	40.2
Score Mid-Test	58.0	56.6	58.6	59.5
Score End-Test	69.7	71.3	69.3	73.8
Change Pre-Mid	+13.6	+12.5	+10.9	+19.3
Change Mid-End	+11.7	+14.7	+12.7	+14.3
Change Pre-End	+25.3	+27.2	+23.6	+33.6
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	15-95	20-90	20-105	

Group I - Power exercises.

Group II - Power exercises followed by endurance exercises.

Group III - Endurance exercises followed by power exercises.

Group IV - Endurance exercises.

TABLE 15  
FIVE-MILE SPEED MARCH  
(Unit: Hour, Minute, and Second)

GROUP	I	II	III	IV
Score Pre-Test	None	None	None	None
Score Mid-Test	1:08:11	1:06:02	1:06:59	1:08:04
Score End-Test	58:47	59:38	59:26	60:10
Change Pre-Mid	None	None	None	None
Change Mid-End	-7:24	-6:24	-7:33	-7:54
Change Pre-End	None	None	None	None
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	None	55:32-1:32:06	45:01-1:23:55	

Group I - Power exercises.  
 Group II - Power exercises followed by endurance exercises.  
 Group III - Endurance exercises followed by power exercises.  
 Group IV - Endurance exercises.

TABLE 16  
OBSTACLE COURSE  
(Unit: Minutes and Seconds)

GROUP	I	II	III	IV
Score Pre-Test	3:00	3:05	3:04	2:58
Score Mid-Test	2:50	2:45	2:47	2:41
Score End-Test	2:39	2:34	2:38	2:31
Change Pre-Mid	- :10	- :20	- :17	- :17
Change Mid-End	- :11	- :11	- :09	- :10
Change Pre-End	- :20	- :31	- :26	- :27
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	2:14-4:20	2:02-4:32	1:55-4:13	

Group I - Power exercises.  
 Group II - Power exercises followed by endurance exercises.  
 Group III - Endurance exercises followed by power exercises.  
 Group IV - Endurance exercises.

TABLE 17  
TREADMILL: RUNNING TIME  
(Unit: Minutes and Seconds)

GROUP	I	II	III	IV
Score Pre-Test	6:21	6:25	6:23	6:20
Score Mid-Test	6:33	6:35	6:35	6:33
Score End-Test	6:44	6:43	6:43	6:43
Change Pre-Mid	+ :12	+ :10	+ :12	+ :13
Change Mid-End	+ :11	+ :08	+ :08	+ :10
Change Pre-End	+ :23	+ :18	+ :20	+ :23
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	5:05-7:40	5:45-8:34	5:50-8:54	

Group I - Power exercises.  
 Group II - Power exercises followed by endurance exercises.  
 Group III - Endurance exercises followed by power exercises.  
 Group IV - Endurance exercises.

TABLE 38

INITIAL PULSE RATE  
(Unit: Beats per 30 Seconds)

GROUP	I	II	III	IV
Score Pre-Test	87	87	87	87
Score Mid-Test	85	85	85	85
Score End-Test	86	86	85	86
Change Pre-Mid	-2	-2	-2	-2
Change Mid-End	+1	+1	±0	+1
Change Pre-End	-1	-1	-2	-1
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	78-97	71-97	73-96	

TABLE 39

TREADMILL: RECOVERY TIME  
(Unit: Minutes)

GROUP	I	II	III	IV
Score Pre-Test	10.4	7.7	9.0	9.2
Score Mid-Test	8.4	7.4	8.3	8.3
Score End-Test	8.0	8.8	7.9	7.4
Change Pre-Mid	-2.0	-0.3	-0.7	-0.9
Change Mid-End	-0.4	-0.6	-0.4	-0.9
Change Pre-End	-2.4	-0.9	-1.1	-1.0
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	5-21	4-20	3-18	

TABLE 40

TREADMILL: RESPIRATION RATE, INITIAL COUNT  
(Unit: Respiration per 30 Seconds)

GROUP	I	II	III	IV
Score Pre-Test	19	19	19	18
Score Mid-Test	21	21	21	21
Score End-Test	21	21	20	21
Change Pre-Mid	+2	+2	+2	+3
Change Mid-End	±0	±0	-1	±0
Change Pre-End	+2	+2	+1	+3
Range of Scores for Entire Group	Pre-Test	Mid-Test	End-Test	
	12-31	13-36	15-39	

TABLE 41  
TREADMILL RESPIRATION RATE, LAST COUNT  
(Unit: Respiration per 30 Seconds)

GROUP	I	II	III	IV
Score Pre-Test	12	13	13	13
Score Mid-Test	14	14	12	13
Score End-Test	12	13	13	13
Change Pre-Mid	+ 2	+ 1	- 1	± 0
Change Mid-End	- 2	- 1	+ 1	± 0
Change Pre-End	± 0	± 0	± 0	± 0
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	7.27	6.21	5.18	

Group I - Power exercises.

Group II - Power exercises followed by endurance exercises.

Group III - Endurance exercises followed by power exercises.

Group IV - Endurance exercises.

SIGNIFICANCE TESTS FOR RESPIRATION RATE-LAST COUNT

	Sum of Squares	df	F
Pre-Test - Mid-Test	31	3	7.95
Scores	492	112	
Mid-Test - End-Test	41	3	3.04*
Scores	503	112	
Pre-Test - End-Test	4	3	0.23
Scores	648	112	

\*The 5% level of significance = 2.70

TABLE 42  
LACTIC ACID  
(Unit: Milligrams Per Cent)

GROUP	I	II	III	IV
Score Pre-Test	None	None	None	None
Score Mid-Test	79.9	85.8	73.7	76.5
Score End-Test	72.8	59.7	66.0	66.1
Change Pre-Mid	None	None	None	None
Change Mid-End	7.1	-26.1	-7.7	-19.4
Change Pre-End	None	None	None	None
Range of Scores	Pre-Test	Mid-Test	End-Test	
for Entire Group	None	26.0-182.0	23.1-125.0	

Group I - Power Exercises.

Group II - Power exercises followed by endurance exercises.

Group III - Endurance exercises followed by power exercises.

Group IV - Endurance exercises.

SIGNIFICANCE TESTS FOR LACTIC ACID

	Sum of Squares	df	F
Pre-Test - Mid-Test			
Scores			
Mid-Test - End-Test	6,372.84	3	2.99*
Scores	71,853.25	102	
Pre-Test - End-Test			
Scores			

\*The 5% level of significance = 2.70

IX. APPENDICES

APPENDIX A  
SELECTION OF SUBJECTS

**A. Selection of the Four Exercise Groups**

For comparison purposes on an experimental basis, the total group, or company, was subdivided into four similar groups through a method of random selection. Initially, it was assumed that this group of men represented the "average" basic training outfit, and that their geographic origin or civilian employment, in no way hindered the efficiency of the sample.

Four sub-samples of 35 each were to be chosen from a total of 140 men. It was decided that the standard Army Physical Fitness Test (APFT) would serve as the basis for stratification. The APFT is a reliable series of five tests designed to measure the physical fitness of an individual. Since all tests were used to measure the effect of various exercises in relation to body efficiency, the equation of the four groups with physical fitness as a base was the primary aim.

In order to insure maximum similarity in selection and to eliminate bias in doing so, three major steps were involved. Initially, the APFT was administered to the entire Test Company, and resulting total scores were ranked accordingly (highest to lowest). The second step was, in a sense, preventive so as to avoid a poor choice due to the chance factor involved in random selection. The 140 men, ranked as explained above, were subdivided into consecutive groups of four men each, so that out of each unit of four, each man would be assigned to a different exercise group. In this way, clumps of men with high or low scores would not be predominant in any one group, as might arise through simple random selection from the ranked column.

Finally, individual selection from each unit of four to be assigned to the various exercise groups was done with a table of random numbers.

**B. Test Subjects Dropped During Study**

There was a total of 24 men dropped from the project for various reasons, as given below.

Two men were dropped before the project was started because of physical disability so severe as to prevent any except the mildest physical activity. Two men were dropped because of injuries received in an automobile accident. Five men started the training and had to be dropped

because of old knee injuries which became so severe as to prevent their doing the exercises. Three men were dropped because of excessive company duty which caused them to miss almost all the physical training. Seven men were dropped because of hospitalization for various illnesses which caused them to miss over 10 days of training. Two were dropped because of administrative transfer. One was dropped because of excessive tachycardia following the first run on the treadmill. One was dropped because of a neuropsychiatric condition resulting in separation from the service. One man was dropped because of an inguinal hernia which became painful following heavy exercise.

APPENDIX B  
EXERCISE PROGRAM

**A. Endurance Exercises**

The endurance program was designed on the premise that endurance can best be produced by a program of high-repetition exercises requiring a minimum amount of strength. The exercises were simple to learn and relatively easy to perform.

The endurance exercises which were chosen were taken primarily from the Army Field Manual 21-20, November 1950. The material it presents is easily understood and is adaptable to large groups of men.

Seven types of endurance exercises were used as described by FM 21-20. They were arranged in weekly schedules so that each type was performed at least once per week and not over three times per week. This was done to relieve monotony and to enable the men to get as much out of the exercises as possible. Two of the seven exercise groups, the twelve conditioning exercises and running, were used more extensively than the other five. It was felt that these two groups of exercises would best develop endurance.

The first of the groups of endurance exercises was the Daily Dozen, or conditioning exercises. These exercises were chosen primarily because they could be conducted anywhere and without equipment. In the Daily Dozen, there were fourteen exercises arranged in proper sequence for best results. The exercises are described and illustrated in FM 21-20, on pages 45 through 60.

The second group of exercises consisted of running, cross-country running and wind sprints, and stationary running.

The third and fourth groups of exercises were made up of rifle and wand exercises. The men were required to memorize all the exercises so that they could go through them in a continuous fashion. The rifle exercises are to be found on pages 76 through 107, in FM 21-20. The only difference in the rifle and wand exercises is the substitution of the rifle for a wand. The wands were used during the early weeks of training more extensively than rifles.

The fifth and sixth groups of exercises consisted of guerrilla exercises and grass drills. An explanation and illustrations can be found on pages 150 through 165, in FM 21-20. These exercises are adaptable to any terrain with many formations and variations.

The seventh group of exercises was made up of games which were used for endurance training as well as for variation. Examples of these were speedball, mass soccer, touch football, American ball, basketball, and volley ball.

B. Endurance Exercise Schedule

1. Types of Exercises

- a. Dd--Daily dozen
- b. Ri--Rifle exercises
- c. W--Wand
- d. Gr--Grass drills
- e. Gu--Guerrilla exercises
- f. R--Running (distance or cross-country)
- g. Ga--Games

2. Performance and Supervision of Exercises

a. Daily Dosen.--These exercises began with 5 repetitions of 12 exercises and worked up to 16 repetitions of 12 exercises.

b. Rifle Exercises and Wands.-- These supplemented daily dozen initially during the first 4 weeks. The last 6 weeks they provided an hour of exercise in themselves.

c. Guerrilla Exercises and Grass Drill. -- These were given one or two times per week, usually preceded by a warm-up period.

d. Running (Cross-Country or Distance). --The subjects ran 100 paces and walked 300 paces the first and second periods, then gradually reversed the time spent on walking.

e. Games.--These were used to supplement the free exercises.

3. Weekly Schedule

Day	Hour	Exercise
Monday	1st	Dd--Introduction to exercise and explain purpose.
	3rd	Running--A short turn about 1 to 1 1/2 miles.
Tuesday	1st	Rifle and wand--Warm up with Dd.
	8th	Grass drills--Dd.

<u>Day</u>	<u>Hour</u>	<u>Exercise</u>
<u>Wednesday</u>	<u>1st</u>	Guerrilla--Warm-up with Dd.
	<u>8th</u>	Running--Cross-country.
<u>Thursday</u>	<u>1st</u>	Grass drills and guerrilla exercises.
	<u>8th</u>	Wand or rifle exercises.
<u>Friday</u>	<u>1st</u>	Dd and games (relays).
	<u>8th</u>	Running--Cross-country.

#### 4. 10-Week Exercise Schedule

##### WEEKS

<u>Day</u>	<u>Hour</u>	<u>1st</u>	<u>2nd</u>	<u>3rd</u>	<u>4th</u>	<u>5th</u>	<u>6th</u>	<u>7th</u>	<u>8th</u>	<u>9th</u>	<u>10th</u>
<u>Mon</u>	<u>1st</u>	Dd	Gr-Dd	Ri-W	R	Ge	Dd	R	Gr-Ge	Ri-Dd	R
	<u>8th</u>	R	Ri-Dd	R	Ge	Dd	Gr-Ge	Ri-W	Dd	R	Dd
<u>Tues</u>	<u>1st</u>	Ri-Dd	R	Gr-Ge	Dd	Ri-D	R	Gr-Ge	R	Ge	Ri-Dd
	<u>8th</u>	Gr	Ge	Dd	Ri-Dd	R	Ri-Dd	Dd	Ge	Ri-W	Ge
<u>Wed</u>	<u>1st</u>	Ge-Dd	Dd	R	Gr-Ge	Ge-Dd	Ge	Ri-Dd	R	Dd	R
	<u>8th</u>	R	Ri-W	Ge	R	R	Dd	Ge	Ri-W	R	Gr-Ge
<u>Thurs</u>	<u>1st</u>	Gr-Ge	R	Dd	Ri-W	Gr-Ge	R	R	Dd	Gr-Ge	Dd
	<u>8th</u>	Ri-W	Gr-Ge	Ri-Dd	R	Ri-W	Ge-Dd	Dd	R	Dd	Ri-W
<u>Fri</u>	<u>1st</u>	Dd	R	Ge-Dd	Ge-Dd	R	R	Ge-Dd	Gr-Dd	R	R
	<u>8th</u>	R	Dd	R	Dd	Dd	Ri-W	R	Ri-Dd	Ge-Dd	R

#### C. Power Exercises

The strength program was built on the premise that power is best developed with a high-resistance, low-repetition exercise program. Therefore, it was decided to use the barbell exercises exclusively in the strength program. To determine the initial weight to be used by each man, DeLorme's method of determining the man's ten repetition maximum was used (4).

The first course consisted of 10 exercises divided into three groups according to weight increases. Upon the completion of each group, there was a weight increase of 50 per cent, which meant that there was a 100 per cent increase in weight during the last group of three exercises. The second course of ten exercises was more vigorous and the weights were increased. A schedule and detailed description of the two weight courses can be found in "Simplifie System of Barbell Training," by Hoffman (21).

A program was used which was similar to the endurance exercise schedule as far as time (length of exercise period and time during day)

was concerned. Each man followed a set procedure but on an individualized weight program. This was necessary due to individual differences in strength, since a man must begin with a weight which he can comfortably handle and yet accomplish a maximum amount of work. Each man performed the three groups of exercises twice per day for a 5-week period. An individual record was kept of what each man lifted every day.

<u>Course No. 1</u>	<u>Repetitions</u>
1. Two Hands High Pull-Up	(10-15)
2. Side-to-Side Bend	(10 to each side)
3. Two Hands Regular Curl	(10-15)
4. Stiff-Leg Dead Lift (Increase weight 50%)	(15)
5. Two-Hand Military Press	(10-15)
6. Shoulder Shrug	(15-20)
7. Rowing Motion	(10-15)
8. Raise on Toes (Increase weight 50%)	(30)
9. Straddle Lift	(10-15)
10. Regular Deep-Knee Bend	(10-15)

This program was followed for one week, twice each day, after which there was a new weight increase. After the completion of the first set of three exercises, there was a weight increase of 50 per cent for the next set of four exercises. When these four exercises had been completed, there was a 50 per cent increase for the last set of three exercises. The course continued for 5 weeks.

<u>Course No. 2</u>	<u>Repetitions</u>
1. Two-Hand Press Complete	(10-15)
2. Two-Hand Reverse Curl	(10-15)
3. Barbell Teetotum	(10-15)
4. Press from Behind Neck (Increase weight 50%)	(10-15)
5. Two-Hand Repetition Snatch	(10-15)
6. Barbell Bend-Over	(10-15)
7. Upright Rowing Motion	(10-15)
8. Regular Deep-Knee Bend (Increase weight 50%)	(10-15)
9. Barbell Straddle Hop	(10-15)
10. Rapid High Dead Lift	(10-15)

The second course was conducted in a manner similar to Course No. 1. It continued for the second 5 weeks of the training period.

Group No. I followed Course No. 1 for the first 5 weeks, and then completed Course No. 2 during the second 5 weeks.

Group No. II followed Course No. 1 for the first 5 weeks of the exercise program only.

Group No. III followed Course No. 1 for the second 5 weeks of the exercise program only.

Group No. IV did not follow the strength program.

## APPENDIX C

### DETAILS OF TEST PROCEDURES

#### A. MEDICAL HISTORIES

The medical histories and physical examinations were done by completing Standard Forms 88 and 89, which are forms prepared by the Bureau of the Budget for use by all Federal Agencies for complete medical histories and physical examinations. The personal histories were taken on prepared forms, a copy of which is shown below.

PERSONAL HISTORY		
NAME _____	ASN _____	GROUP _____
DATE OF BIRTH _____	PLACE OF BIRTH _____	
SCHOOL		
Age Begun School _____	Years Missed _____	
Years Skipped _____	Highest Grade Reached _____	
Technical or Other Schooling _____		
Main Interest in School _____		
WORK		
Jobs Held (type & salary)	Date	Degree of Exertion
1. _____		
2. _____		
3. _____		
4. _____		
ATHLETICS		
Sport _____	Degree of Interest _____	Team, hours/day, etc. _____
1. _____		
2. _____		
3. _____		
ACTIVITY FOR PAST THREE MONTHS _____		
FAMILY		
Father's Age _____	Occupation _____	
Mother's Age _____	Occupation _____	
Brother's Age _____	Occupation _____	
Brother's Age _____	Occupation _____	
Sister's Age _____	Occupation _____	
Sister's Age _____	Occupation _____	
Married/Single _____		
Wife's Age _____	Occupation _____	
Children, Age & Sex _____ _____ _____		
REMARKS:		

B. DETERMINATION OF HEMATOCRIT

The hematocrit was determined by the method of Winthrobe (22).

C. DETERMINATION OF HEMOGLOBIN

Hemoglobin was determined by the brownish color of acid hematin produced upon treatment of the blood with hydrochloric acid. This method is a spectrophotometric adaptation based on the method of Sahli (23, 1905). A Coleman Junior Model Spectrophotometer was used.

D. ARMY PHYSICAL FITNESS TEST

The Army Physical Fitness Test was run as described in Par. 156, FM 21-20, November 1950. Exercises used were pull-ups, squat jumps, push-ups, sit-ups, and the 300-yard run. The exercises were given in this order. One assistant directed and scored each exercise. All were done inside a gymnasium except the 300-yard run, which was run outdoors on an asphalt pavement. The indoor tests were done without boots. Scoring was done on the prepared card, DA AGO Form 705, 1 June 1949. The raw score was the number of repetitions of each test or the time for the run. The point score was then found by comparing raw score and point score on the back of the card. The point score was the one used for comparison of groups.

E. MUSCLE POWER TEST

Before being tested, each man was thoroughly oriented on the testing procedure and told what was expected of him when performing the muscle test. All the men completed the test of the tricep and quadricep muscles on the first day, and the bicep and hip flexors the following day. The hand grip was determined at various times during the test period.

The men were given time to warm up the muscles being tested before taking the test. This prevented muscle strain or injury.

To determine the one repetition maxim, the subject had to move the maximum weight through a prescribed range of motion for each muscle tested. The range of motion is stated below in each muscle description.

The weight selected initially was empirically set by the tester. If the man succeeded in lifting it through the required range of motion, additional weights were added until a maximum was reached. The man was not asked to lift the weights more than 3 or 4 times without a rest period. It was felt that after four pulls through the range of motion he reached a plateau as far as maximum pull was concerned, after which his strength maximum diminished.

#### 1. Biceps

a. Position. --The subject was supine on the table, feet toward the pulley weights; upper arm flat on table, lower arm at 45-degree angle to the table (this was the arm that was being tested). The arm that was not being tested was flat on the table, palm down. Legs were stabilized just below the knees by an assistant. The upper part of the arm being tested was also stabilized by the tester. The handle was grasped with palm toward the head. Prior to test, the man demonstrated his full flexion.

b. Test. --From a 45-degree angle of the forearm to the table, flex elbow completely.

c. Resistance. --The resistance is an adjustable group of lead weights on a movable pulley.

#### 2. Triceps

a. Position. --The subject was supine, head toward pulley weights; upper arm flat on the table, elbow fully flexed; opposite arm flat on the table, palm down. Both legs were stabilized just below the knees by an assistant. The upper part of the arm being tested was stabilized by the tester.

b. Test. --Hand grasps handle, palm faces feet. Extend elbow to complete extension.

c. Resistance. --The resistance was an adjustable group of lead weights on a movable pulley.

#### 3. Quadriceps

a. Position. --Seated with knees flexed over edge of table, upper body and legs formed an angle of approximately 130 degrees. Hands

rested on table about 6 inches behind and slightly outside of hips. Stabilizing belt attached across hips when subject was in the sitting position. Iron boot attached to foot, with foot and boot resting on footstool to relieve initial weight.

b. Test. --Foot and boot were removed from footstool and allowed to hang over edge of table; knee joint extended to full extension without thigh rotation.

c. Resistance. --An iron boot with adjustable barbell weights.

#### 4. Hip Flexors

a. Position. --Seated with knees flexed over the end of the table, hands rested on table at sides of hips. Back was straight, body and legs formed a 90-degree angle at hips. Stabilizing belt attached across hips when man was in the sitting position. A strap attached to the weights was placed around the leg 4 inches above the knee.

b. Test. --The thigh was flexed on the hip in a 50-degree arc.

c. Resistance. --Adjustable lead weights were attached to strap which was around leg.

#### 5. Hand Dynamometer

a. Position. --Subject took the hand dynamometer in right or left hand. He used the same hand each time he took the test. The dynamometer was held away from the body.

b. Test. --The dynamometer was squeezed as hard as possible for the best out of three scores.

c. Resistance. --Springs in dynamometer.

#### F. ANTHROPOLOGICAL MEASUREMENTS

Heights and weights were determined on the standard clinical scale, with the subject wearing only a pair of shorts. The remaining measurements were all circumferential measures done with a standard clinical tape to the nearest quarter of an inch. The neck was measured just below the thyroid cartilage. The chest was measured at the nipple line in the natural position, full expiration and full inspiration. The abdomen was measured at the umbilicus in natural position. The upper arm was measured at the largest swelling of the biceps, once with the arm hanging relaxed and once with the elbow flexed to 90° and the upper arm tensed.

The forearm was measured relaxed at the largest point. The thigh was measured relaxed at the mid-point from the knee to the anterior-superior iliac spine. The calf was measured relaxed at the largest point. All measurements were done by the same assistant.

#### G. THE HARVARD STEP TEST

This was carried out by having each man step up and down on a 20-inch step at a rate of 120 per minute, for 5 minutes, or until the subject stopped. Heart rate was then counted for 30 seconds, beginning one minute after stopping. The score was then read from the prepared chart, a copy of which is shown below (2).

Harvard Step Test Scoring Table

Duration of Effort	Heartbeats From 1 Min. to 1 1/2 Min. in Recovery									
	40	45	50	55	60	65	70	75	80	85
1	44	49	54	59	64	69	74	79	84	89
0' - 29"	5	5	5	5	5	5	5	5	5	5
0'30" - 0'59"	20	15	15	15	15	10	10	10	10	10
1'00" - 1'29"	30	30	25	25	20	20	20	20	15	15
1'30" - 1'59"	45	40	40	35	30	30	25	25	20	20
2'00" - 2'29"	50	50	45	45	40	35	35	30	30	25
2'30" - 2'59"	70	65	60	55	50	45	40	40	35	35
3'00" - 3'29"	85	75	70	60	55	55	50	45	45	40
3'30" - 3'59"	100	85	80	70	65	60	55	55	50	45
4'00" - 4'29"	110	100	90	80	75	70	65	60	55	50
4'30" - 4'59"	125	110	100	90	85	75	70	65	60	55
5'	130	115	105	95	90	80	75	70	65	60

#### H. THE 5-MILE SPEED MARCH

This was run individually by the test subjects. The men were started on the course at one-minute intervals. Each man was instructed to cover the course as rapidly as possible. The course was well marked. The exact length of the course was 5.6 miles. It included two hills, with a climb of approximately 300 feet each. It was run on a gravel road. Many of the subjects overtook and passed men in front of them. How much this altered the motivation of each subject is hard to evaluate.

#### I. THE 20-MILE HIKE

This was taken as a unit. Rate of march was 2-1/2 miles in 50 minutes, followed by a 10-minute rest period. A 30-minute break was taken at meal time. Observations of general condition and ability to hike were recorded on each test group by each cadre man present.

## J. THE OBSTACLE COURSE

This was run on an individual basis. Initially, the subjects were given as much time as they wished to become familiar with the various obstacles. They were then started over the course and timed. They were not allowed to practice after the initial test. A description of the course is given below.

There are 10 obstacles to cross in the order given below. The whole course was 1207 feet long.

1. Tire Run. -- Twelve tires were arranged in a regular pattern. Tires were laid next to each other in two rows. The subjects were required to place a foot in each tire.
2. Ditch No. 1. -- The ditch was 15 feet wide and 8 feet deep. The sides were rough and irregular. The subjects were required to cross this ditch.
3. Wall. -- The wall was 7-1/2 feet high and 1 inch thick. The subjects were required to go over the wall.
4. Swing. -- A ditch 3 feet deep and 10 feet across had a rope hanging from overhead bar. The subjects were required to swing across ditch. An assistant kept the rope swinging so it could be reached.
5. Second Wall. -- The wall was 5-1/2 feet high and 1 foot thick across top. Subjects were required to go over the wall.
6. Log Jump. -- A series of six logs were placed various distances apart, each 4 feet from ground at top of log. From the beginning to the end it was 57 feet long. Subjects were required to go over logs.
7. Ditch No. 2. -- The ditch was 4 feet wide and 5 feet deep. Subjects were required to go over ditch.
8. Tunnel. -- The tunnel was 2-1/2 feet square and 20 feet long. Subjects were required to crawl through tunnel.
9. Zig Zag Run. -- The running course was outlined by rails 3-1/2 feet apart. Zig zag run was 123 feet long, with 6 changes of direction of 35-40 degrees each.
10. Ladder. -- The ladder was horizontal 8 feet above ground, 20 feet long, and 2 feet wide. Subjects were required to go the length of ladder while hanging by hands.

#### K. THE TREADMILL TEST

This was administered by having the subject walk on a motor-driven treadmill at a rate of 3.5 mph for 5 minutes at a 15 per cent grade, and then run at 7 mph until exhausted. The subjects wore combat boots and fatigue clothing, but carried no pack. At the completion of the test, the subject stepped off the treadmill and sat down. Pulse and respiration were counted immediately for 30 seconds and repeated for 30 seconds out of each minute, until the pulse was below 100 per minute.

#### L. DETERMINATION OF BLOOD LACTIC ACID

Blood lactic acid levels were determined by conversion of the lactic acid to acetaldehyde and subsequent reaction with p-hydroxydiphenal to induce color in the solution<sup>(24)</sup>.

##### 1. Procedure

a. Five cc of whole, oxalated blood was removed from the subject and immediately placed in a 10 cc test tube with the crystals of 0.5 cc of K-NH<sub>4</sub> oxalate solution. Samples of blood which could not be analyzed immediately were kept under refrigeration (-20°C) until tested.

b. Nine cc portions of 10 per cent trichloroacetic acid were pipetted into 15 ml centrifuge tubes.

c. One cc portion of blood sample was pipetted into the trichloroacetic acid dropwise while agitating the tube slowly (for blank 1 ml distilled HOH was used).

d. The solution was allowed to stand 5 minutes while being shaken intermittently to insure reaction. Then it was centrifuged in an International No. 2 centrifuge at 1500 rpm's for approximately 5 minutes.

e. Transfer was made of 0.5 ml aliquots of this centrifugate to 15 ml centrifuge tubes. By means of a pipette, 1 ml portion of 20 per cent CuSO<sub>4</sub> solution was added to each sample.

f. The solution was diluted to 10 cc with distilled HOH (addition of 8-1/2 ml). Then 1 gram of Ca(OH)<sub>2</sub> was added and the solution shaken for 30 seconds.

g. The solution was allowed to stand for 30 minutes, being shaken at 10-minute intervals, then centrifuged for approximately 5 minutes at 1500 rpm's.

h. Transfer was made of 1 ml aliquot portion of centrifugate to 6" pyrex test tubes and 0.05 ml (4%) CuSO<sub>4</sub> added (1 drop from a dropper prepared to deliver 20 drops per ml); and 8 ml concentrated H<sub>2</sub>SO<sub>4</sub> was slowly added while agitating until well reacted and mixed.

i. Tubes were placed in a boiling HOH bath for 5 minutes and then cooled to below 20°C. When well cooled, 0.1 ml p-hydroxydiphenyl (2 drops from graduated eye dropper) was added.

j. Tubes were placed in HOH at 25°-30°C for about 30 minutes to enhance color development, meanwhile shaking to insure uniform dispersion of indicator ions. (Note: Solution should be violet blue; a pink or red violet color indicates temperature of ion development was too high.)

k. Test tubes were placed in boiling HOH bath for about 90 seconds (solution became clear and red violet).

l. The solution was cooled to room temperature (cold running water bath was used, but placing under tap HOH or in sink is satisfactory); transfer was made of the sample to optical curvettes and absorbency measured on Coleman Spectrophotometer, with setting at 565 m $\mu$ . The optical density was recorded and a plot was made on a previously prepared standard curve.

## 2. Possible Sources of Error

The method used is a very precise but delicate one. A number of precautions not ordinarily employed should be exercised. Clean glassware, free of any skin contact, must be used throughout. All diverse metallic ions must be noted and excluded. Their effect on color enhancement is notable. Order of reagent addition, reaction time, volume measurement of solutions, heating and cooling time must be carefully standardized.

To avoid error, the glassware should be washed in (a) tap water, (b) conc. H<sub>2</sub>SO<sub>4</sub> bath for 6 hours, (c) tap water, (d) distilled HOH.

The p-hydroxydiphenyl ions must be thoroughly dispersed in the acetaldehyde solution and permitted to develop at a temperature below 20°C if maximum color development is to be obtained.

The H<sub>2</sub>SO<sub>4</sub> used must be of A.C.S. grade, added from an automatic reservoir burette free of stopcock grease.

After color is developed, heating at boiling temperatures must not be continued longer than 2 minutes since it destroys the ion.

Fresh gauze sponges are recommended for cleaning glassware, and glass-stoppered vessels should be used to keep solutions free from contamination.

Solutions should be vigorously mixed, especially after addition of the p-hydroxydiphenyl to  $H_2SO_4$ , as it is quite insoluble and must be uniformly dispersed if accurate results are desired.

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